

**GODDARD SPACE FLIGHT CENTER  
CRYOGENICS PROGRAM OVERVIEW**

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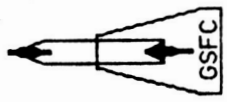
APRIL 28, 1987

PRESENTED BY  
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N88-15926

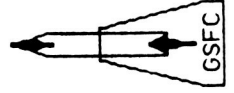
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## **OUTLINE**

- GSFC FLIGHT PROGRAMS
- GSFC CRYOGENIC COOLER TECHNOLOGIES
- LONG TERM STORAGE OF CRYOGENS
- NEW LIQUID CRYOGEN COOLER TECHNOLOGY
- LIQUID HELIUM SERVICING



## LIST OF ACRONYMS

ADR	Adiabatic Demagnetization Refrigerator
AF	Air Force
ARC	Ames Research Center
AXAF	Advanced X-Ray Astrophysics Facility
BASD	Ball Aerospace Systems Division
BBXRT	Broad band X-Ray Telescope
CLAES	Cryogenic Limb Array Etalon Spectrometer
COBE	Cosmic Background Explorer
DIRBE	Diffuse Infrared Background Experiment
EOS	Earth Observing System (Polar Platform)
EVA	Extra Vehicular Activity
FIRAS	Far Infrared Absolute Spectrometer
HIMS	Hubble Imaging Michelson Spectrometer
HIRIS	High Resolution Infrared Spectrometer
H.Q.	Headquarters (NASA)
IRAC	Infrared Array Camera
IRAS	Infrared Astrophysics Satellite
JSC	Johnson Space Flight Center
KSC	Kennedy Space Flight Center
LMSC	Lockheed Missiles and Space Corporation
MMC	Martin Marietta Corporation
MODIS-N	Moderate Resolution Imaging Scanner Nadir
MSFC	Marshall Space Flight Center
NBS	National Bureau of Standards
NICMOS	Near Infrared Camera and Multiple Object Spectrometer
PAMF	Particle Astrophysics Magnet Facility (Astromag)
SAC	Solid Argon Cooler
SCC	Solid Cryogen Cooler
SHOOT	Superfluid Helium On Orbit Transfer Flight Demonstration
SIRGE	Shuttle Infrared Glow Experiment
SIRTF	Space Infrared Telescope Facility
SKIRT	Spacecraft Kinetic Infrared Test
SS	Space Station
ST	Space Telescope
UARS	Upper Atmosphere Research Satellite
VMS	Vacuum Maintenance System
XRS	X-Ray Spectrometer

## **GODDARD'S ROLE**

- o PROVIDE LEADERSHIP IN AEROSPACE CRYOGENIC COOLER TECHNOLOGY
  - DEVELOP ADVANCED COOLING SYSTEMS AND SUPPORTING TECHNOLOGY
  - ASSIST IN THE TRANSFER OF NEW TECHNOLOGY TO INDUSTRY
- o SUPPORT GODDARD PROJECTS REQUIRING CRYOGENIC COOLERS AND FLUID SYSTEMS
- o SUPPORT GODDARD PROJECTS REQUIRING THE DEVELOPMENT AND TESTING OF INSTRUMENTS AND SENSORS OPERATING AT CRYOGENIC TEMPERATURES

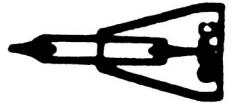
## **GSFC FLIGHT PROGRAMS REQUIRING CRYOGENICS**

### **FLIGHT PROJECTS - ON GOING**

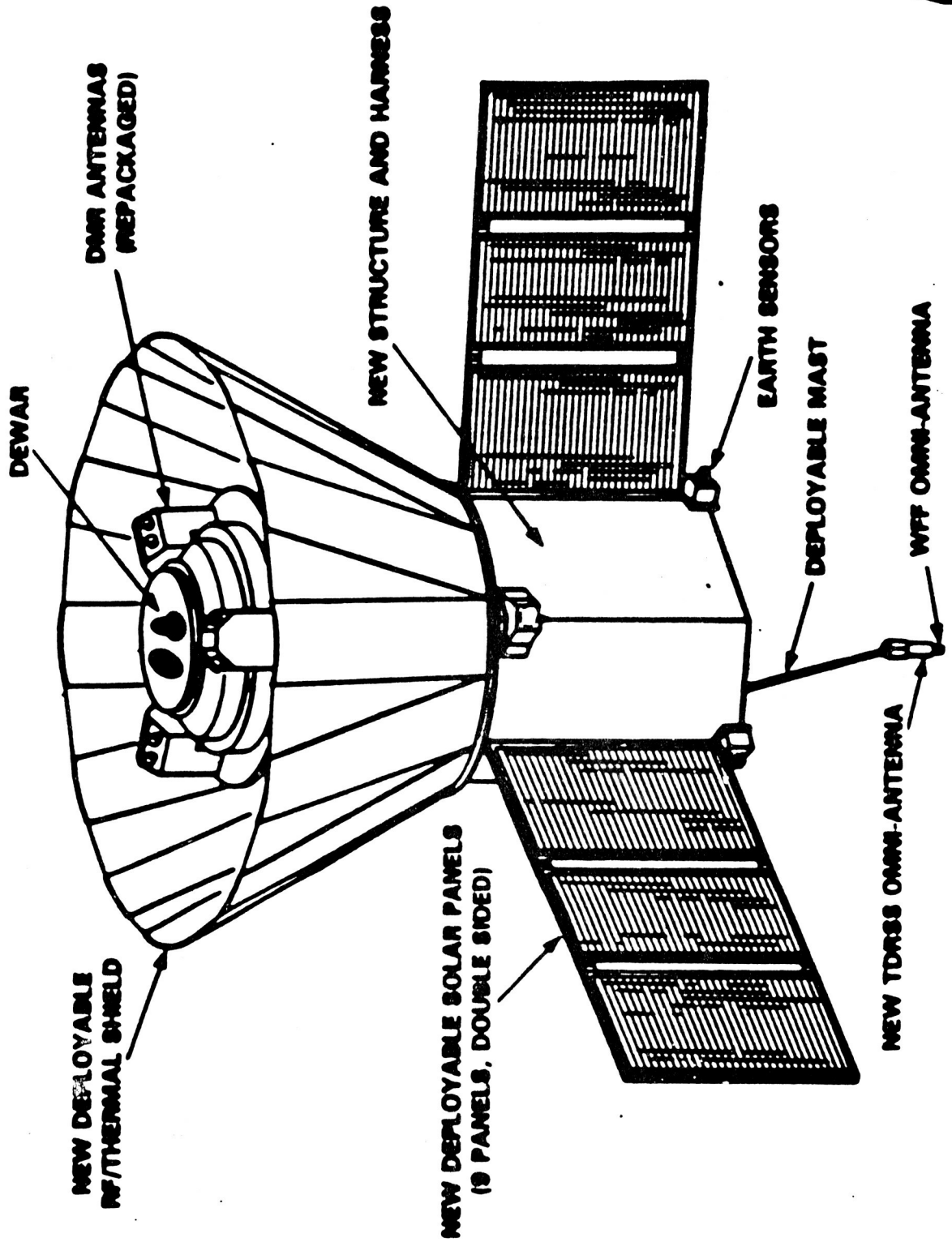
- o COBE (FIRAS AND DIRBE)
- o UARS (CLAES)
- o BBXRT
- o LHe SERVICING FLIGHT DEMONSTRATION (SHOOT)

### **FLIGHT PROJECTS - START-UP PHASE**

- o AXAF (XRS)
  - MECHANICAL COOLER
  - HELIUM DEWAR
  - ADR
- o EOS (MODIS AND HIRIS)
- o SECOND GENERATION SPACE TELESCOPE INSTRUMENTS (NICMOS,HIMS)
- o SKIRT

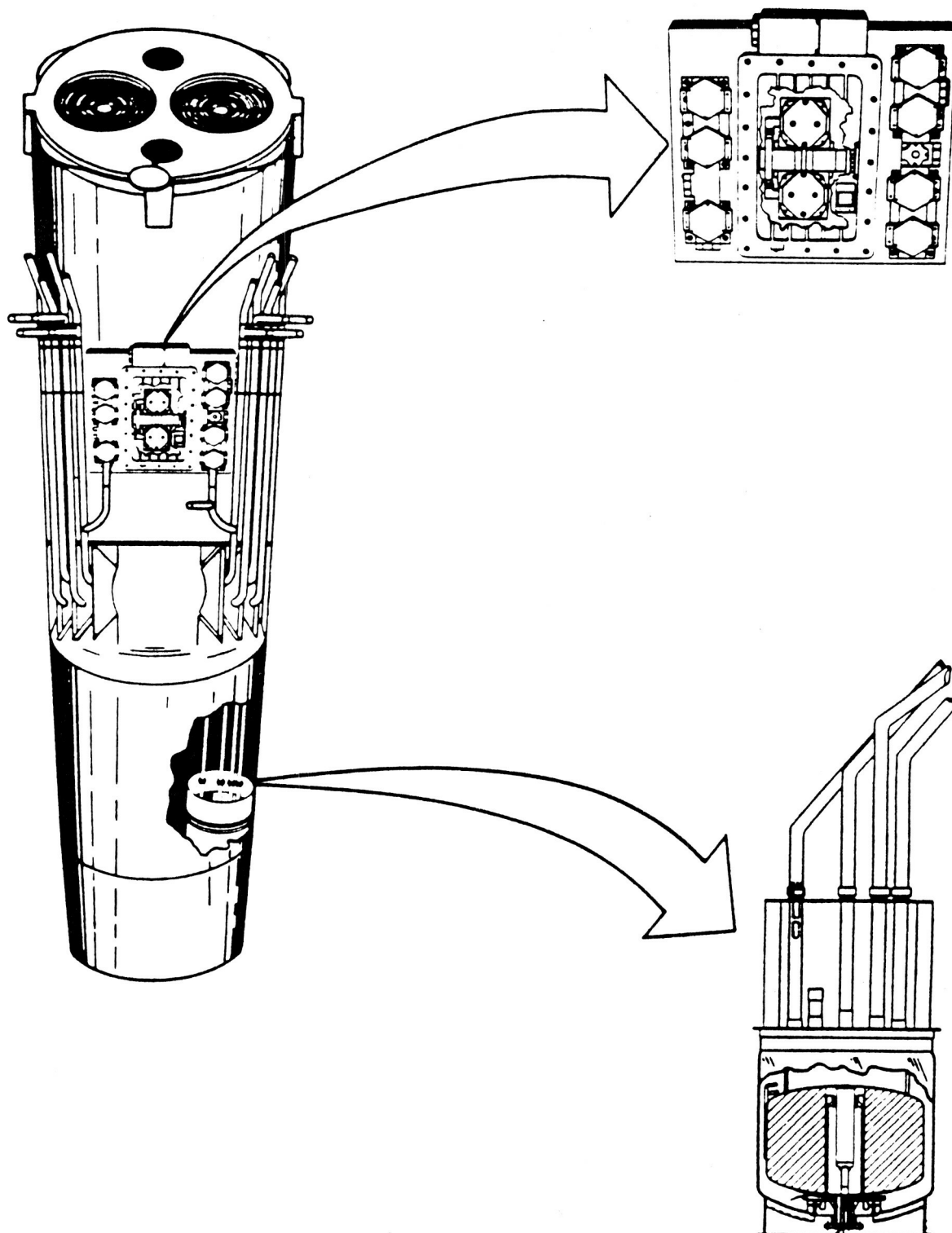


## COBE/DELTA CONFIGURATION

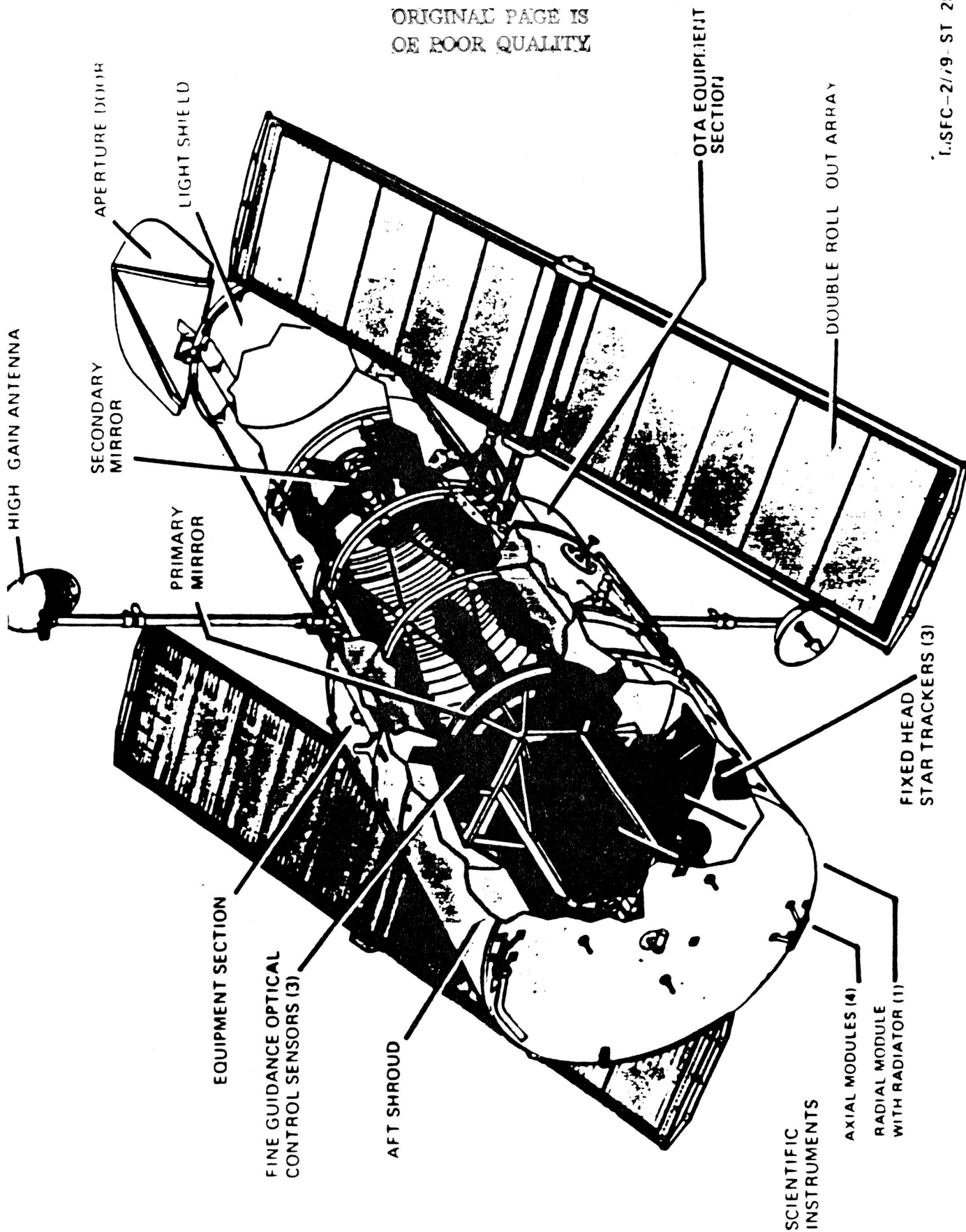


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## BBXRT SAC/VMS



# SPACE TELESCOPE CONFIGURATION

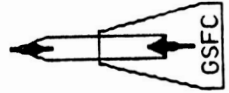


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# **GSFC FLIGHT PROGRAMS REQUIRING CRYOGENICS** **(CONTINUED)**

## **FLIGHT PROJECTS - LONG TERM**

- o ASTROMAG
- o SIRTf (IRAC)
- o CRITICAL POINT EXPERIMENT
- o LIQUID HELIUM SERVICING



## **GSFC AEROSPACE COOLER TECHNOLOGY**

### **10 - 120K**

- o SOLID CRYOGEN COOLERS: 10 - 120K (UARS, BBXRT)
- o SURFACE TENSION CONFINED LIQUID CRYOGEN COOLERS: 10-120K
- o SINGLE STAGE MECHANICAL COOLERS: 40 - 120K (AXAF, EOS)
- o MULTISTAGE MECHANICAL COOLERS: 2 - 40K

### **0.1 - 4K**

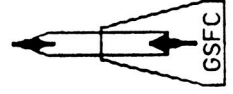
- o LONG LIFE LIQUID HELIUM DEWARS: 2K (COBE, AXAF, ASTROMAG)
- o ON-ORBIT LIQUID HELIUM TRANSFER (11 PAYLOADS, INCLUDING AXAF, SIRTf, ASTROMAG, LDR)
- o ADIABATIC DEMAGNETIZATION REFRIGERATORS: 0.1K (AXAF, SIRTf)

## **OTHER MAJOR GSFC CRYOGENIC SPECIALTIES**

- o BOLOMETERS
- o TEMPERATURE SENSOR CALIBRATION
- o MATERIAL THERMAL PROPERTY MEASUREMENTS
- o SUPPORT FOR OTHER DISCIPLINES AT THE GSFC DESIGNING INSTRUMENTS OPERATING AT CRYOGENIC TEMPERATURES

## **GSFC FACILITIES**

- CRYOGENICS LABORATORY
  - CRYOGENIC COOLER DEVELOPMENT
  - INSTRUMENT TESTING AT CRYOGENIC TEMPERATURE
  - SENSOR DEVELOPMENT AND CALIBRATION
- LIQUID HELIUM SERVICING TEST BED
- REMOTE TEST SITE
  - HAZARDOUS OPERATIONS AND TESTS



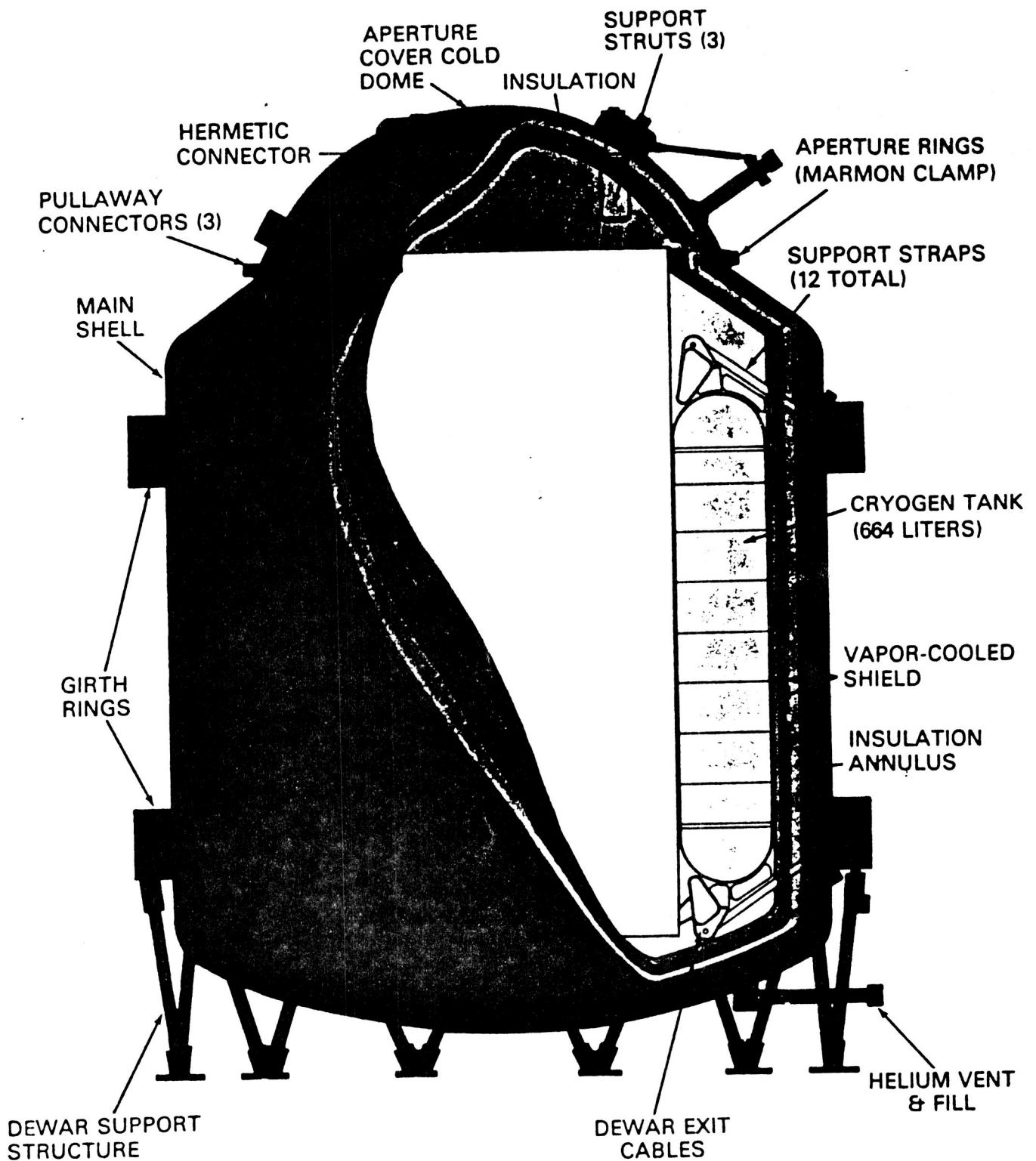
## **GSFC MECHANICAL COOLER PROGRAM**

- o GODDARD IS DEVELOPING LONG LIFETIME SPACE FLIGHT QUALIFIED MECHANICAL COOLERS THROUGH CONTRACTS WITH INDUSTRY
  - PHILIPS LABORATORIES AND CREARE INC. ARE PRESENTLY UNDER CONTRACT
- o THE GSFC MECHANICAL COOLER PROGRAM WILL BE DISCUSSED IN A SEPARATE PRESENTATION

## **LONG LIFETIME SUPERFLUID HELIUM DEWARS**

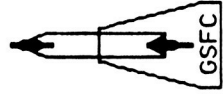
- o ONE LONG LIFETIME SUPERFLUID HELIUM DEWAR HAS FLOWN (IRAS)
  - THE IRAS DEWAR HAD A 10 MONTH LIFETIME
- o TWO SMALL DEWARS FLEW ON SPACELAB-2
- o THE COBE DEWAR HAS BEEN FABRICATED, TESTED AND DELIVERED TO THE GSFC
  - THE COBE DEWAR HAS A 14 MONTH LIFETIME
- o FUTURE MISSIONS SUCH AS AXAF, SIRTf, ASTROMAG, LDR, ETC., WILL HAVE MISSION LIFETIMES OF UP TO 15 YEARS

## COBE DEWAR SYSTEM LAYOUT



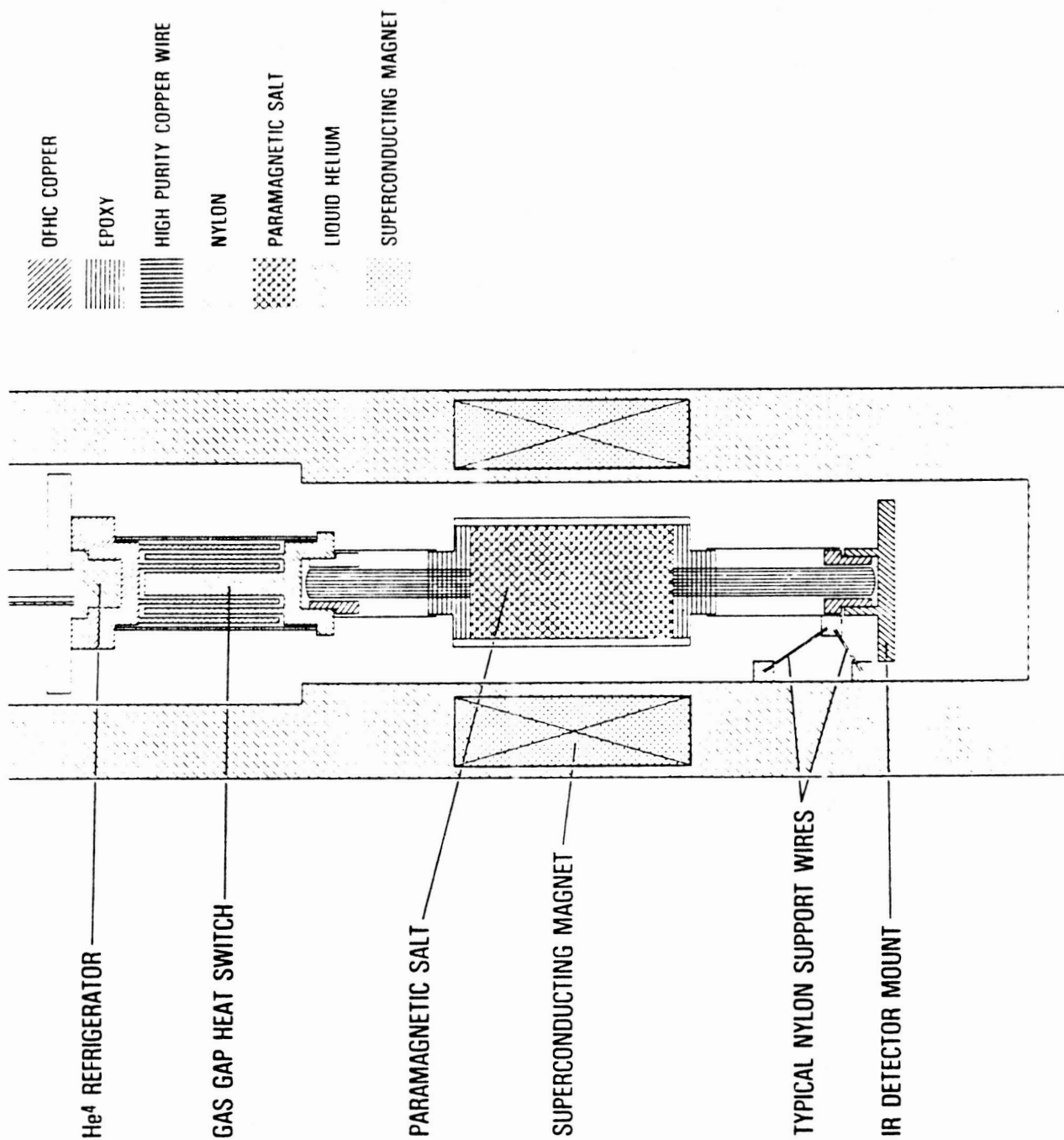
## **ADIABATIC DEMAGNETIZATION REFRIGERATOR**

- o A TECHNOLOGY DEMONSTRATION MODEL ADR HAS BEEN FABRICATED AND TESTED IN-HOUSE AT THE GSFC
- o SEVERAL KEY TECHNOLOGIES WERE IDENTIFIED FOR FURTHER DEVELOPMENT
  - SHOULD BE COMPLETED IN 1987
- o AN ADR WILL BE REQUIRED BY INSTRUMENTS ON AXAF AND SIRTf



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# GSFC ADIABATIC DEMAGNETIZATION REFRIGERATOR



## **SOLID CRYOGEN COOLERS**

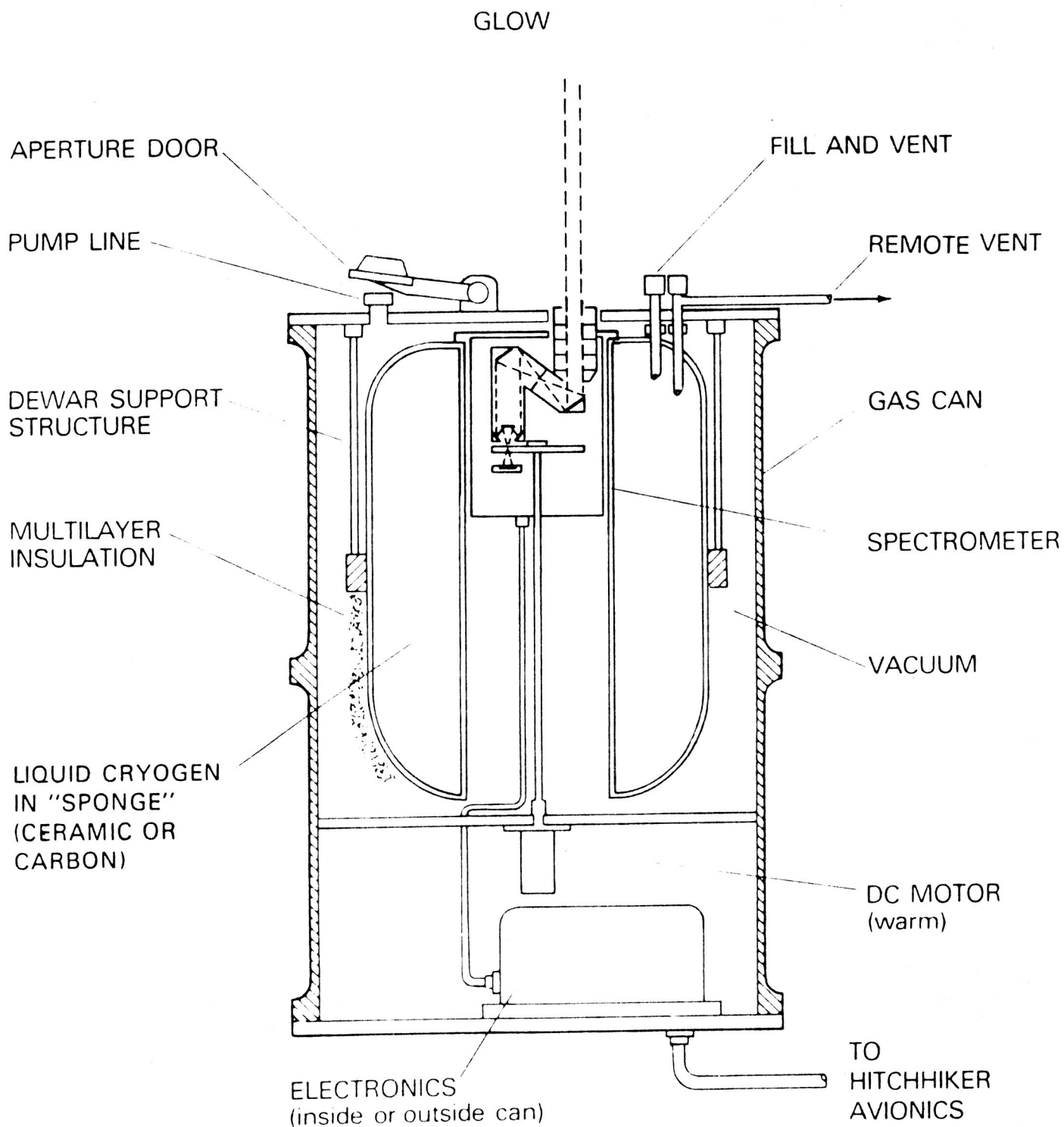
- o SOLID CRYOGEN COOLERS REPRESENT THE OLDEST CRYOGENIC FLIGHT COOLER TECHNOLOGY
  - 4 NASA METHANE-AMMONIA COOLERS HAVE FLOWN
  - NO SOLID CRYOGEN COOLER HAS YET FLOWN ON THE SHUTTLE
- o GSFC IS MONITORING THE PRODUCTION OF SOLID CRYOGEN COOLERS FOR 2 PROJECTS
  - LOCKHEED IS PRODUCING A LARGE NEON/CARBON DIOXIDE COOLER FOR UARS (CLEAS)
  - BEECH (NOW BALL) IS PRODUCING A PAIR OF ARGON COOLERS FOR BBXRT

## **SURFACE TENSION CONFINED**

### **LIQUID CRYOGEN SYSTEM**

- o GSFC IS DEVELOPING A NEW TYPE OF COOLER THAT MAY REPLACE SOLID CRYOGEN COOLERS
  - A SURFACE TENSION CONFINED LIQUID CRYOGEN COOLER
- o THIS TECHNOLOGY MAY BE APPLICABLE TO MOST 2 PHASE LIQUID CRYOGEN SYSTEMS
  - THE GOAL IS TO PROVIDE SIMPLIFIED ON ORBIT SERVICING

# SURFACE TENSION CONTAINED LIQUID CRYOGEN COOLER FOR SHUTTLE GLOW EXPERIMENT



## **LIQUID CRYOGEN COOLER ADVANTAGES AND DISADVANTAGES**

### **ADVANTAGES:**

- POTENTIALLY REFILLABLE IN ORBIT
- NO GROUND HOLD TIME LIMITATIONS
- SIMPLE GROUND SERVICING OPERATIONS
- NO SLOSHING OF LIQUID ON-ORBIT

### **DISADVANTAGES:**

- SPONGE USES UP TANK VOLUME
- SPONGE MAY BE A CONTAMINATION SOURCE
- UNTESTED THERMAL AND MECHANICAL BEHAVIOR

### **SPONGE PROPERTIES**

	<b><u>GOAL</u></b>	<b><u>TEST RESULTS</u></b>
• DENSITY	SMALL	7 LBS/FT <sup>3</sup>
• FREE VOLUME (VOLUME AVAILABLE TO CRYOGEN)	> 95%	90%
• WICKING HEIGHT	HIGH	2 INCHES
• STRENGTH, RIGIDITY	HIGH	FAIR
• THERMODYNAMIC EFFECTS	NONE	NONE
• THERMAL EXPANSION AND CONTRACTION	SMALL	SMALL
• VIBRATION EFFECTS	NONE	TBD
• PARTICULATE COUNT AND SIZES	FEW AND LARGE	TBD

## **POTENTIAL PAYLOADS**

### **LONG DURATION MISSIONS:**

- SECOND GENERATION SPACE TELESCOPE EXPERIMENTS
- SPACE STATION (MAN TENDED EXPERIMENTS)

### **SHUTTLE SORTIE MISSIONS:**

- SPACE KINETIC INFARED TEST
- NEAR INFRARED SPECTROMETER

## **LIQUID CRYOGEN COOLER PROGRAM**

### **ACCOMPLISHMENTS:**

- TESTS OF THE THERMODYNAMIC AND MECHANICAL BEHAVIOR OF CANDIDATE SPONGE MATERIALS (ONE CARBON, ONE CERAMIC)
- IDENTIFICATION OF OTHER AVAILABLE OR POTENTIAL SPONGE MATERIAL CANDIDATES

### **PRESENT WORK:**

- AN SBIR CONTRACT HAS BEEN AWARDED TO INVESTIGATE CARBON SPONGE MATERIAL MICROSTRUCTURE
- DEVELOPING DESIGN TO ADDRESS CONCERNS INHERENT IN A SPACE QUALIFIED COOLER

## **LONG DURATION MISSIONS**

### **o TECHNIQUES TO EXTEND THE LIFETIME OF MISSIONS REQUIRING CRYOGENIC COOLING INCLUDE:**

- o CHANGE OUT THE PAYLOAD STORED CRYOGEN COOLER ON-ORBIT
  - NOT FEASIBLE FOR MANY PAYLOADS BECAUSE OF POTENTIAL MISALIGNMENT OF THE INSTRUMENT
- o RETURN THE PAYLOAD TO EARTH FOR SERVICING
  - NOT COST EFFECTIVE
- o RELIQUIFY THE BOIL-OFF
  - NOT PRESENTLY BEING PURSUED BECAUSE OF LARGE POWER REQUIREMENT
- o REPLACE THE CRYOGEN WITH ACTIVE COOLING
  - GODDARD IS DEVELOPING A MECHANICAL COOLER FOR THE 40K TO 120 K TEMPERATURE RANGE
  - MULTISTAGE MECHANICAL COOLERS USING PRESENT TECHNOLOGY REQUIRE SEVERAL KILOWATTS OF POWER TO PROVIDE COOLING AT LIQUID HELIUM TEMPERATURES
- o REPLENISH THE CRYOGEN ON-ORBIT
  - DEVELOPMENT OF THIS OPTION HAS BEGUN FOR LIQUID HELIUM
- o USE A MECHANICAL COOLER TO INTERCEPT A PORTION OF THE PARASITIC HEAT LOAD
  - BEING IMPLEMENTED FOR LONG LIFETIME LIQUID HELIUM DEWARS

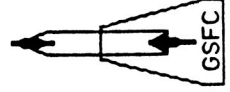
## **LONG DURATION MISSIONS:**

### **SUMMARY OF**

### **APPROACHES BEING PURSUED**

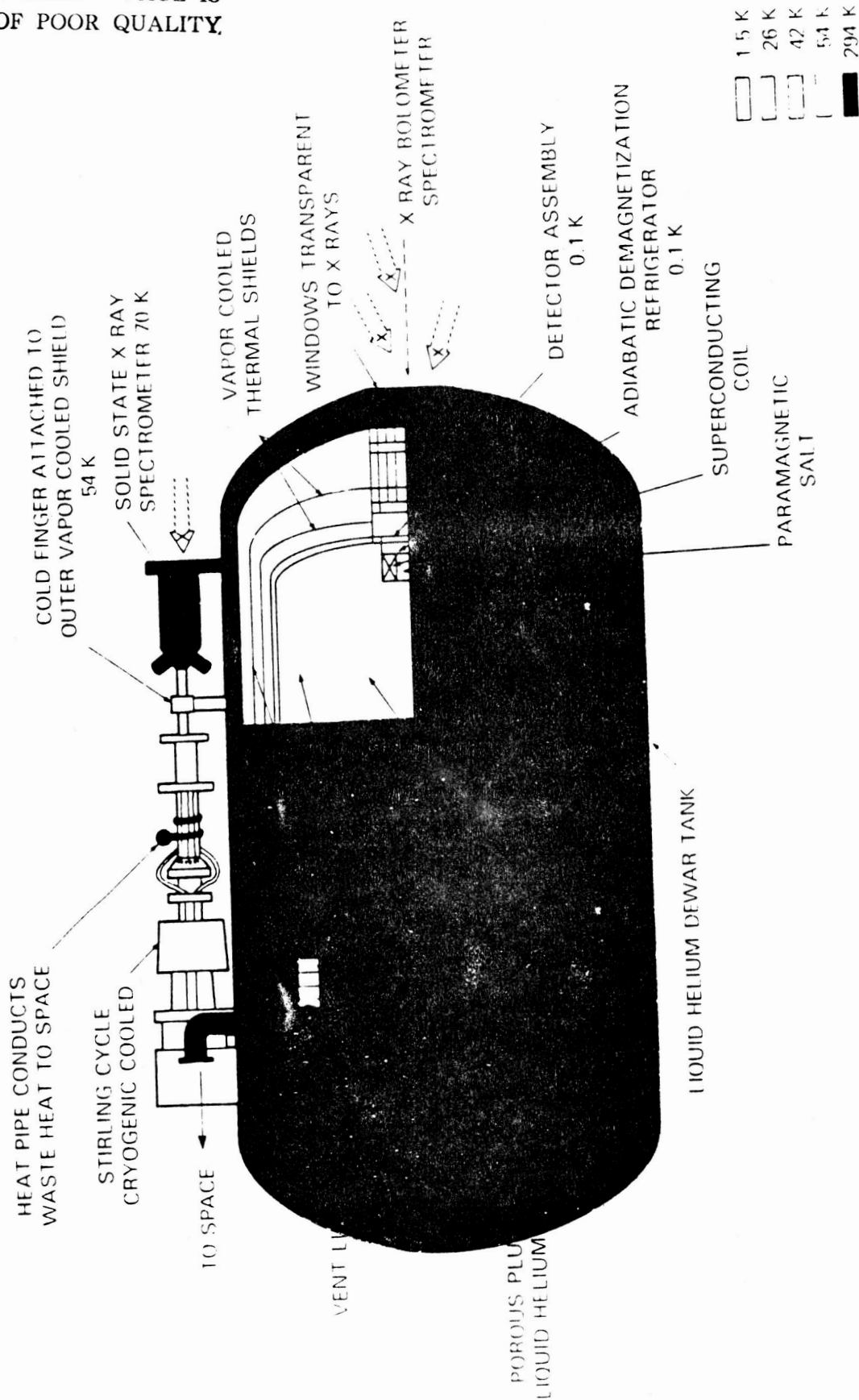
#### **0.1 - 2K**

- o THE CAPABILITY TO REFILL PAYLOADS WITH LIQUID HELIUM IS BEING DEVELOPED
  - 11 MISSIONS HAVE REQUESTED SERVICING WITH LIQUID HELIUM
- o THE USE OF A MECHANICAL COOLER TO INTERCEPT THE PARASITIC HEAT LOAD HAS BEEN BASELINED FOR THE XRS INSTRUMENT
- o MOST LONG LIFETIME PAYLOADS REQUIRING LIQUID HELIUM MAY USE BOTH APPROACHES



# THE X-RAY SPECTROMETER ON THE ADVANCED X-RAY ASTROPHYSICS FACILITY

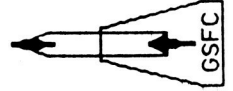
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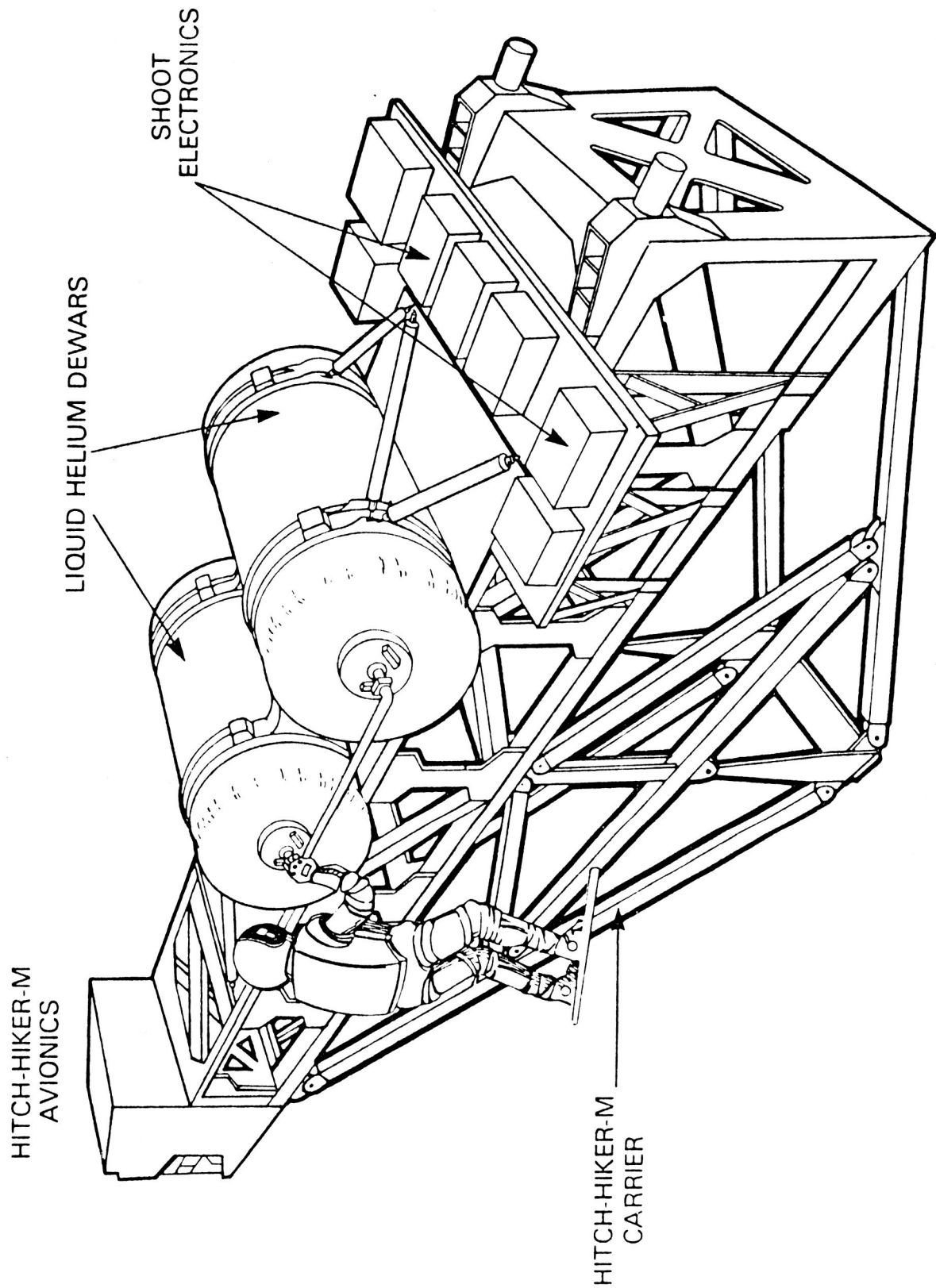
# **SUPERFLUID HELIUM ON ORBIT TRANSFER (SHOOT)**

## **FLIGHT DEMONSTRATION**

- o SHOOT IS AN STS BASED FLIGHT DEMONSTRATION PROGRAM DESIGNED TO DEMONSTRATE THE TECHNOLOGY REQUIRED FOR LIQUID HELIUM SERVICING IN SPACE. THE SHOOT PROJECT IS FUNDED BY THE OFFICE OF SPACE FLIGHT (CODE M) AT NASA HEADQUARTERS.
- o SHOOT IS A JOINT EFFORT BETWEEN THE GODDARD SPACE FLIGHT CENTER (GSFC), AND THE AMES RESEARCH CENTER (ARC) WITH SUPPORT FROM THE JOHNSON SPACE CENTER (JSC) AND THE MARSHALL SPACE FLIGHT CENTER (MSFC) AND THE KENNEDY SPACE CENTER (KSC).



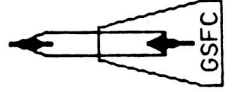
# SUPERFLUID HELIUM ON ORBIT TRANSFER FLIGHT DEMONSTRATION



## **SUPERFLUID HELIUM ON ORBIT TRANSFER**

### **FLIGHT DEMONSTRATION PRIMARY REQUIREMENTS**

- DEMONSTRATE THE CRITICAL COMPONENTS AND OPERATIONS OF THE CRYO-SERVICING KIT.
- DEFINE THE REQUIREMENTS THAT MUST BE MET BY THE USER PAYLOADS TO ENSURE THAT THE PAYLOADS ARE SERVICEABLE.



# LHe SERVICING USERS SCHEDULE (AS OF 12/86)

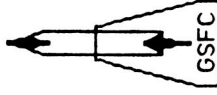
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SHOOT DEVEL.																					
STS FLIGHT DEMO																					
CRYO SERVICING KIT PREPHASE A																					
PHASE A STUDY																					
PHASE B STUDY																					
PHASE C/D																					
AXAF LAUNCH He SERVICING																					
SIRTF LAUNCH He SERVICING																					
ASTROMAG LAUNCH He SERVICING																					
LDR LAUNCH He SERVICING																					
LAMBDA POINT EXP. LAUNCH He SERVICING																					
MATS. FACILITIES LAUNCH He SERVICING																					

**SUPERFLUID HELIUM ON ORBIT TRANSFER**  
**MISSION OBJECTIVES**

- o DEMONSTRATE LIQUID HELIUM TRANSFER
  - DEMONSTRATE 500 L/HR TRANSFER RATE
  
- o DEMONSTRATE FLUID CONTAINMENT TECHNIQUES
  - CONTAIN SUPERFLUID HELIUM DURING HIGH RATE TRANSFER RATE
  - CONTAIN NORMAL LIQUID HELIUM DURING COOLDOWN OF THE RECEIVER DEWAR
  
- o DEMONSTRATE FLUID ACQUISITION SYSTEM
  - PROVIDE FLOW TO THE PUMP AT 500 L/HR
  
- o DEMONSTRATE MASS GAUGING
  - HEAT PULSE
  - SUPERCONDUCTING WIRE WITH BENEFICAL SETTLING
  
- o DEMONSTRATE FLOW MEASUREMENT TECHNIQUES
  
- o DEMONSTRATE EVA TRANSFER LINE COUPLER
  
- o DEMONSTRATE REMOTE AND/OR AUTONOMOUS OPERATIONS

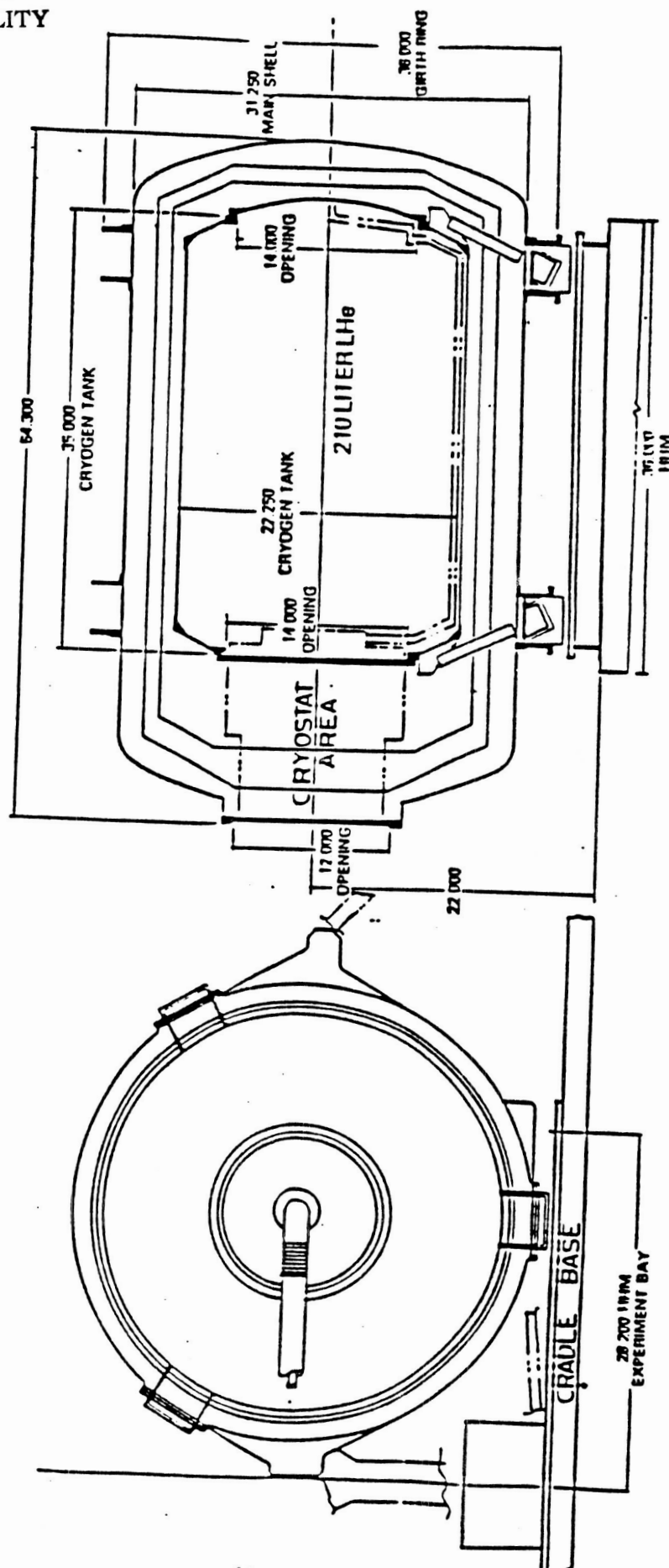
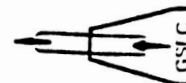
## **DEWARs**

- o TWO 210 LITER CAPACITY DEWARs.
- o APPROXIMATELY 100 MW PARASITIC HEAT LEAK ACHIEVABLE WITH VACUUM SHELL AT 300 K.
- o TWO VAPOR COOLED SHIELDS.
- o FIBERGLASS STRAP SUPPORTED CRYOGEN TANK.
- o MODULAR CONSTRUCTION FOR EASY ACCESS TO CRYOSTAT.
- o PLUMBING, VALVES, PLUGS, ETC. CONTAINED IN REMOVABLE CRYOSTAT.



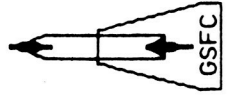
# SHOOT LIQUID HELIUM DEWAR

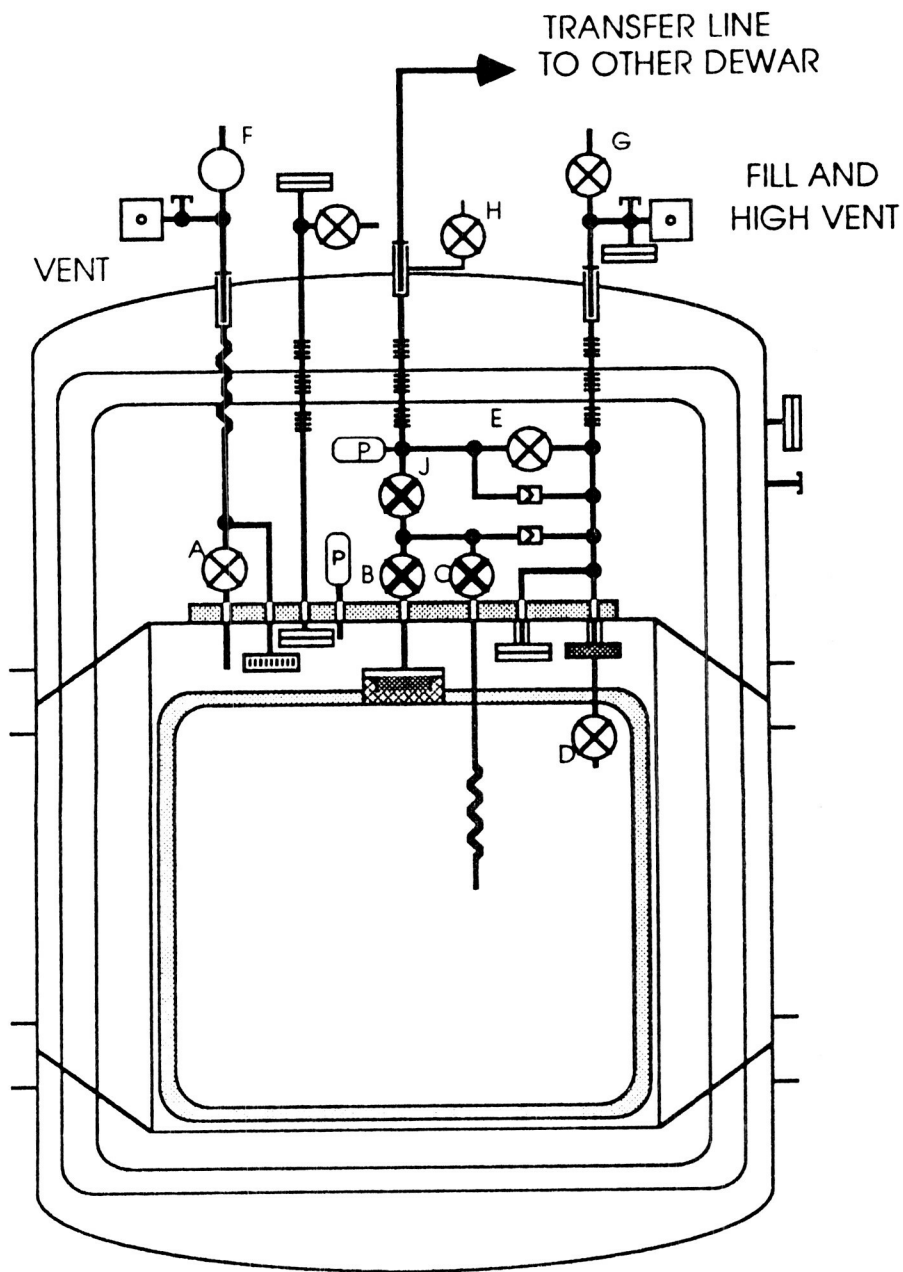
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## **CRYOSTAT**

- o ALL PLUMBING, VALVES, PUMP, POROUS PLUGS, ETC.
- o 1/2 INCH DIAMETER TRANSFER LINE AND FILL AND VENT LINES.
- o 3/4 INCH DIAMETER HIGH FLOW RATE VENT LINE.
- o 5 CRYOGENIC VALVES AND 3 WARM VALVES.
- o COLD AND WARM BURST DISCS.
- o EVA SFHe COUPLERS.
- o OTHER COMPONENTS: PRESSURE TRANSDUCERS, GRITS. HEATERS, WIRING, ETC.

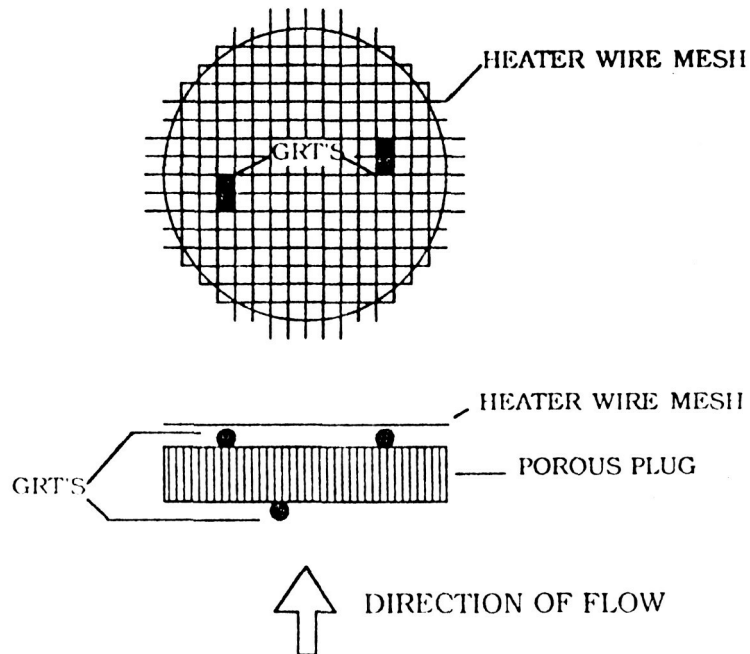




SHOOT DEWAR AND CRYOSTAT LAYOUT



## THEROMECHANICAL EFFECT PUMP SCHEMATIC



### THERMOMECHANICAL EFFECT PUMP TEST RESULTS

- LIMITED BY SIZE OF TEST BED VACUUM PUMP AND TM PUMP
  - TEST BED HAS 1300 CFM PUMP
- 3 INCH DIAMETER TM PUMP PROVIDED 218 LITER PER HOUR FLOW RATE

## **NORMAL/SUPERFLUID PHASE SEPARATOR**

**(A THERMODYNAMIC VENT)**

### **STATUS**

- NARROW SLITS FABRICATED USING HIGH PURITY (99.999%) COPPER
  - PRESENT TESTS HAVE DEMONSTRATED 95% EFFICIENCY UNDER WORST CASE (HIGH PRESSURE AND LOW TEMPERATURE) CONDITIONS
  - IMPROVEMENTS EXPECTED TO BE ACHIEVED BY IMPROVED FABRICATION TECHNIQUES
- ALSO FABRICATING SOLID COPPER DISKS WITH SMALL PORES
  - 1 TO 1.5 MICRON PORES IN OFHC COPPER (ALABAMA CRYOGENIC ENGINEERING)

### **FUTURE WORK**

- WILL TEST BOTH PROTOTYPE IN LAB UNDER WORST CASE CONDITIONS

## **HIGH VENT RATE PHASE SEPARATOR**

- POROUS PLUG WITH LARGE PORE SIZE PROVIDES LIQUID/VAPOR PHASE SEPARATION AT HIGH VENT RATES
  - REQUIRED DURING HIGH FLOW RATE TRANSFERS
- DURING NORMAL OPERATION AN IN-LINE VALVE CLOSES OFF THE HIGH VENT RATE PHASE SEPARATOR
- BASELINE IS STAINLESS STEEL PLUG WITH NOMINAL 8 MICRON PORE SIZE

## **FLUID ACQUISITION SYSTEM**

### **SPONGE**

- CAPILLARY ACTION TESTED FOR SHUTTLE TILE MATERIAL (SILICA)
  - ABLE TO HOLD COLUMN OF HELIUM GREATER THAN 5 CM AGAINST 1 G

### **SCREENED CHANNEL (GALLERY)**

- SMALL SCALE SAMPLE TESTED AT TM PUMP INLET
  - WOVEN STAINLESS STEEL WIRE (DUTCH TWILL WEAVE) WITH HOLE SIZE OF A FEW MICRONS
  - MAINTAINED FLOW TO PUMP INLET AGAINST 4 CM OF NEGATIVE HYDROSTATIC HEAD
  - FURTHER TESTS OF SCREEN SAMPLES WILL DETERMINE TEMPERATURE DROP AND TM CAPABILITIES (OPERATES AS A WEAK TM PUMP)

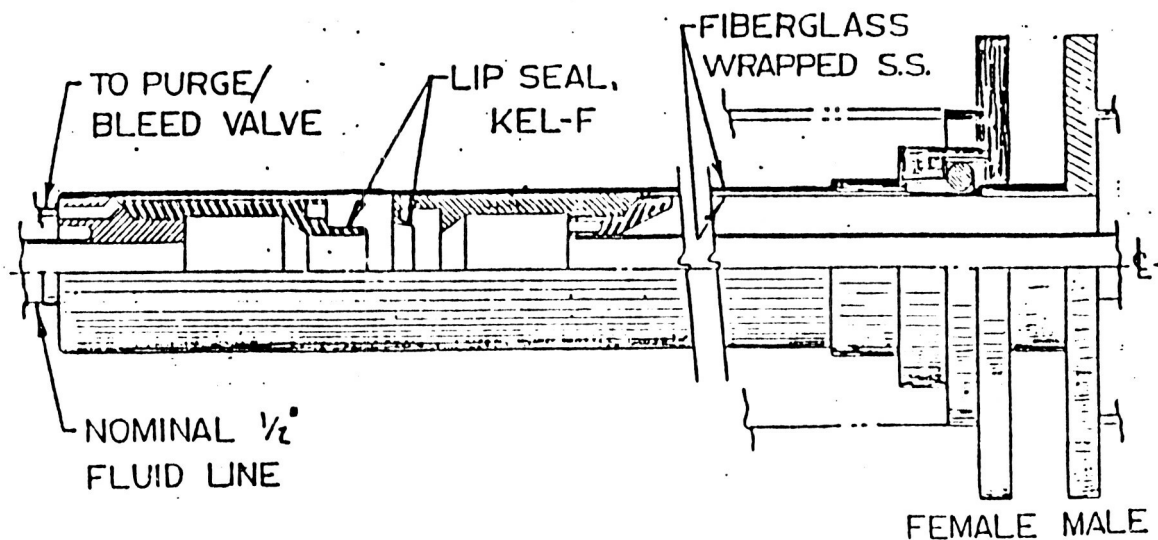
## **EVA ACTIVITY**

- ASTRONAUT WILL DISCONNECT AND CONNECT AN EVA COUPLER IN THE TRANSFER LINE
  - ARC IS MANAGING THE EVA ACTIVITIES
- JSC IS PROVIDING THE EVA COUPLER
  - CRYOLAB HAS PRODUCED A THERMAL MODEL COUPLER FOR THE GSFC

## LOW HEAT LEAK SFHe COUPLER

- DESIGNED FOR < 0.5 WATT HEAT LEAK
- TEST WITH SFHe DEMONSTRATED 0.25 WATT HEAT LEAK
- DESIGNED FOR > 100 PSID PRESSURE IN ANY DIRECTION
- DESIGNED FOR USE WITH HIGH THROUGHPUT, 1/2" NOMINAL TRANSFER LINE
- ABLE TO BLEED OFF TO SPACE ANY RESIDUAL He LEAK AROUND NOSE SEAL

### SFHe LOW HEAT-LEAK COUPLING



## **MASS GAUGING**

- HEAT CAPACITY TECHNIQUE
  - HIGH THERMAL CONDUCTIVITY OF SFHe ALLOWS SHORT RELAXATION TIMES (ABOUT 1 SEC)
  - CONCEPT TESTED IN SPACELAB 2 SFHe EXPERIMENT (BETTER THAN 10% ACCURACY)
  - RESOLUTION OF 1% REQUIRES HIGH PRECISION THERMOMETRY
- SUPERCONDUCTING LEVEL SENSORS
  - OPTIONAL MASS GAUGING WITH BENEFICIAL G SETTLING

## **FLOW METERS**

- VENTURI TYPE METER BEING DEVELOPED BY NBS FOR ARC
- HEAT FLOW TECHNIQUE BEING INVESTIGATED BY THE GSFC
  - TEMPERATURE RISE BETWEEN TWO POINTS IN THE FLOW STREAM INDUCED BY KNOWN HEAT INPUT CAN BE CORRELATED TO FLOW VELOCITY

## **STEPPER MOTOR DRIVEN CRYOGENIC VALVE**

- PROTOTYPE VALVE HAS BEEN DEVELOPED BY UTAH STATE UNIVERSITY UNDER CONTRACT TO GSFC. THE VALVE INCLUDES THE FOLLOWING: 1/2 INCH NOMINAL NUPRO BELLOWS VALVE (SS-8BK-TSW), REDUNDANT STEPPER MOTORS, REDUNDANT END POSITION INDICATORS, AND THE GEAR TRAIN.
- SPECIFICATIONS:
  - OPERATES UNDER VACUUM AND/OR FULLY IMMERSED IN LHe.
  - He LEAK THROUGH SEAT NOT TO EXCEED  $1 \times 10^{-7}$  SCCS AT 4K
  - MAINTAIN ABOVE SPEC. AFTER FOLLOWING TESTS: LAUNCH VIBRATIONS, 25 THERMAL CYCLES (ROOM TEMP TO 4K), 200 OPEN/CLOSE CYCLES AT 4K, AND 300 OPEN/CLOSE CYCLES AT ROOM TEMPERATURE.
- TEST RESULTS TO DATE INDICATE VALVES WILL MEET SPEC.
- HIGHER FLOW CONDUCTANCE VALVES ARE BEING TESTED UNDER THE SAME CONTRACT.

## **SUMMARY**

- GSFC HAS AN ACTIVE CRYOGENIC AND FLUID SYSTEMS TECHNOLOGY PROGRAM.
  - 16 CIVIL SERVANTS IN CRYOGENICS AND 9 IN FLUID SYSTEMS.
- GODDARD CRYOGENIC COOLER TECHNOLOGY IS FOCUSED ON MEETING THE REQUIREMENTS OF NASA'S SCIENTIFIC INSTRUMENTS.
  - SOME TECHNOLOGIES MAY BE APPLICABLE TO OTHER CRYOGENIC FLUID SERVICING APPLICATIONS.
- ON ORBIT CRYOGENIC FLUID SERVICING IS AN INCREASINGLY IMPORTANT TECHNOLOGY TO MEET THE NEEDS OF LONG LIFETIME FACILITIES.

**SPEAKER: STEPHEN H. CASTLES/GODDARD SPACE FLIGHT CENTER**

**John R. Schuster/General Dynamics Space Systems:**

Can you briefly tell us what the status is of your magnetic stirling cyro cooler program?

**Castles:**

Yes, I am going to talk about that in detail tomorrow, so I don't want to get into too much depth. We have an engineering model that has now been running on the shelf for three years unattended. We are producing a flight model, and I'll give you a twenty-minute talk on it tomorrow.

**Dave Chato/Lewis Research Center:**

I was wondering what a bolometer was?

**Castles:**

A bolometer is a detector for the far infrared regions. On COBE we have them that go out to 1 cm. It is a calorimeter device. It absorbs the radiation, and, since it has low heat capacity itself, it warms up and you have a very sensitive temperature sensor. It is essentially a bulk measurement of the heat of the incoming radiation. It is the most sensitive far infrared detector. It turns out you can gain sensitivity, something like  $T$  to the  $-5/2$  power, by going to the lower temperature. So there is a push to go to lower temperatures, as low as .1 Kelvin.

**John Aydelott/Lewis Research Center:**

You indicated that you identified 11 satellites that you felt could use servicing capabilities in the future. Are they all superfluid helium coolers?

**Castles:**

As far as we know, all of them would like to use superfluid. Let me elaborate on that. We have, as an adjunct to our SHOOT Flight Demonstration, a program which is actually funded by Space Station, to do a system level study of servicing for superfluid payloads or for liquid helium payloads. As part of that, we are looking at all the potential payloads, what their requirements are, and various aspects of servicing the particular payloads. We try to look at each particular payload to make sure that we can meet the specific needs. It does appear, based on that study, that superfluid will meet everyone's needs.

**Aydelott:**

Is superfluid helium really required from a scientific point of view, or is that perceived as a way to get around some of the low-gravity fluid management problems?

**Castles:**

What is required is the low temperatures. The sensors need low temperatures, and if you have a 4-Kelvin, normal helium dewar and you want to operate something at lower temperature, then you have to provide some means of

providing cooling at that lower temperature. Their are advantages, in terms of providing cooling power, to flying superfluid just because it is colder. Other than that there is no specific science driver for superfluid, as opposed to the normal helium.

**John P. Gille/Martin Marietta Denver Aerospace:**

With regard to the heat pulse gauging system, would you repeat what accuracy was achieved on Space Lab 2 and then tell me what you consider the potential for that method?

**Castle:**

On Space Lab 2, they did apply heat pulses and just looked at the temperature rise; a 10 percent accuracy was estimated, because their thermometer was not designed to be as precise as you would need for more accuracy. On SHOOT, the accuracy of the thermometry, or the sensitivity, is designed so that we can determine, under worst case conditions, the mass of the helium to 1 percent; we feel that is adequate.